

DENITRIFICATION OF THREE HUNGARIAN SOILS TREATED WITH AMMONIUM NITRATE AT DIFFERENT MOISTURE LEVEL

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Introduction

Denitrification can decrease soil nitrate content significantly by decreasing the efficiency of N-fertilization (Debreczeni et al. 1997). The high nitrogen input to the soils otherwise can be harmful to the subsurface drinking water sources. Denitrification activity of the soils enable decreasing the harm of nitrate leaching, but the biological denitrification is most intensive in the topsoil which is mostly well aerated while the chance of the biological nitrate removal is decreasing with the depth (Németh et al. 1993).

The effects of environmental conditions on the denitrification are still incompletely understood (Simcik et al. 2004). Generally the rate of denitrification enhances with increasing temperature, easily decomposable organic matter, nitrate concentration and pH (Szili-Kovács et al. 1988; Bálint et al. 1995; Nótás et al. 2002) whereas aeration decreases nitrate respiration. Since oxygen and nitrate are alternative electron acceptors for facultative anaerobic bacteria the absence of oxygen is considered as a prerequisite to initiate this process (Ottow 1990). The aim of this work was to investigate the denitrification potential of the top layer of three different types of soils at varying soil moisture and nitrate level experimentally. The soils originated from hydrogeological protection zones of three important water bases in Hungary where the lands cultivated traditionally, which may affect the quality of subsurface water.

Methods

Soils: Halásztelek, Kapuvár and Medgyesbodzás were sampled from the plough layer, air-dried, homogenised and sieved (2 mm mesh). The main properties of the soils were the follows, Halásztelek: pH=7.8, CaCO_3 =6.2%, plasticity (K_A)=28, Organic C=0.88%, Total N=0.11%; Kapuvár: pH=6.8, CaCO_3 =0.0%, plasticity (K_A)=50, Organic C=1.49%, Total N=0.19%; Medgyesbodzás: pH=8.1%, CaCO_3 =4.4%, plasticity (K_A)=48, Organic C=2.32%, Total N= 0.29%.

Experiment: Soils have been moistened to 20, 60 and 100% of their maximum water holding capacities (W20, W60 and W100 treatments) with distilled water or ammonium nitrate solution which were added in 0, 150 and 300 $\mu\text{g N g}^{-1}$ soil (N0, N150 and N300 treatments) concentration. Denitrification was measured by acetylene blockage method (Yoshinari and Knowles, 1976) in laboratory incubation. Acetylene inhibits N_2O -reductase enzyme, so all denitrification gas products ($\text{N}_2 + \text{N}_2\text{O}$) can be measured as N_2O . The flasks were airtight secured and incubated with 5 % acetylene gas at 25°C for 8 days. Cumulative N_2O and CO_2 production was measured after 1, 2, 3 and 8 days of incubation by gas chromatograph equipped with thermal conductivity detector.

Results and discussion

Effect of moisture. It was not surprising, that the highest loss of N was at 100% WHC treatment for all soils (Figure 1). There was no detectable N_2O production at 20 and 60% WHC in Halásztelek sandy soil. At 100% WHC much less nitrous oxide was produced here than in the other two soils. N_2O could be detected at all moisture in Kapuvár while only at 60% and 100% in Medgyesbodzás soil. After 24 hours of incubation only the 100% WHC treatments resulted significant denitrification in all soils. This treatment with no N addition caused the total loss of soil nitrate-N after 48 hours of incubation, which was in agreement with other observations (Simek et al. 2004).

Effect of mineral N added. Mineral N addition to the soils caused a further loss of soil nitrate-N by denitrification but only at the 60% and 100% WHC treatments. In Kapuvár soil there was no difference in N_2O production between 150 and 300 $\mu\text{g N g}^{-1}$ soil additions at 20% WHC. At 60% WHC much faster loss of soil N could be detected at 300 $\mu\text{g N g}^{-1}$ soil. At 100% WHC there was no difference in N_2O production in the first three days, only later in the 8th day with much higher rate at the 300 $\mu\text{g N g}^{-1}$ soil treatment. In contrary, in Medgyesbodzás soil the 300 $\mu\text{g N g}^{-1}$ soil treatment caused a significantly faster and stronger denitrification than the 150 $\mu\text{g N g}^{-1}$ soil treatment at 100% WHC showing nitrate limitation of denitrification here.

In general the Kapuvár soil had the highest denitrification potential, because all treatments showed significant denitrification after the 8th day, while the other two soils not. The denitrification activity in Halásztelek soil was very low.

The different features of denitrification potential among the soils can be explained their different texture and organic matter content (Végh 2005). Table 1 shows that CO_2 concentration during incubation increased in different measure in these soils. The CO_2 concentration in Halásztelek soil was at between 2.6 and 6.3%, while in the most active Kapuvár soil it ranged from 17 to 22 %, in the Medgyesbodzás soil it was in the middle between 2.5 and 10%. Assuming that CO_2 production is in relation with the O_2 consumption the concentration of the oxygen in the incubation flasks would be the main limiting factor for denitrification. However, the organic C was higher in Medgyesbodzás than in Kapuvár, the C mineralization was higher in this latter soil. This may be related with the much better aggregated structure of the Kapuvár soil compared with the Medgyesbodzás soil.

Table 1. Accumulation of CO₂ (volume %) in vessels during incubation at three different moisture and nitrogen level.

Days	Treatments								
	W20 N0	W60 N0	W100 N0	W20 N150	W60 N150	W100 N150	W20 N300	W60 N300	W100 N300
<i>Kapuvár soil</i>									
1	5.27	5.93	4.54	4.91	5.58	4.96	4.95	5.89	4.58
2	9.47	14.74	8.49	8.46	12.47	9.18	9.4	14.96	8.1
3	12.76	20.03	12.21	11.38	16.44	13.04	12.97	20.35	11.21
8	18.83	22.74	20.99	18.53	21.72	20.81	20.12	23.63	17.59
<i>Halásztelek soil</i>									
1	1.7	1.97	0.77	1.49	1.26	1.14	1.29	1.96	1.26
2	2.49	2.61	1.34	2.07	2.23	1.77	1.67	2.82	1.96
3	3.61	3.45	1.84	2.77	2.65	2.21	2.17	3.75	2.65
8	6.25	4.15	3.57	3.71	3.28	2.64	2.71	5.93	3.21
<i>Medgyesbodzás soil</i>									
1	0.58	2.68	1.55	0.64	2.7	3.65	0.76	2.51	2.93
2	0.9	4.51	4.66	0.88	4.65	5.84	1.12	4.12	4.63
3	1.26	7.04	6.19	1.29	6.93	8.06	1.65	6.05	6.61
8	2.49	10.3	8.11	2.39	9.77	9.13	3.12	6.81	9.56

Conclusions

The denitrification potential was influenced by soil moisture and nitrate content of the soils. The denitrification rate was the highest in a well aggregated biologically active Kapuvár soil. Significant denitrification in Halásztelek sandy soil can be only occurred in waterlogged conditions.

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